Abstract

Magnetic fluids have improved the efficiency of chemotherapy when drugs are bound to magnetic nanoparticles and the nanoparticle laden fluid is steered towards tumor regions by means of an external magnetic field. Research at the Cooper Union has focused on the development of a computational fluid dynamics modeling tool for the direct simulation of magnetic fluid flow. This computational tool will be used to gain insight into the complex physical dynamics of ferrohydrodynamic flow and perform simulated experiments of the application of ferrofluid to magnetic drug targeting that are potentially difficult to reproduce experimentally.

This thesis focuses on the algorithm development for the computation of magnetophroretic force from an externally applied field. A new formulation for the body force density is computed from the linear incompressible form of the magnetic stress tensor that decouples the permeability and magnetic fields. This new formulation is validated with a series of validation cases demonstrating droplet deformation in an applied uniform field, multiple droplet interaction in an applied field, and the normal field instability of ferrofluids where a uniform field is applied orthogonal to an interface between a magnetic and nonmagnetic fluid layer. The new formulation shows improved results in modeling large differences in magnetic material properties across an interface.

Additionally a post-processing tool is developed to compute the volume, center of mass, and inertia tensor of an arbitrary number of droplets from the output files of simulation results. The tool was used in the droplet interaction experiment to characterize droplet deformation and displacement and to compute the mutual net magnetophoretic force experience for the multiple droplet test case.